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PROCEEDINGS OF THE PHILADELPHIA FOUNDRYMEN'S ASSOCIATION.

The regular monthly meeting of the Foundrymen's Association was held at the Manufacturers' Club, Philadelphia, on Wednesday evening, March 2, with President P. D. Wanner in the chair.

Mr. Evans called upon the various members present to report upon the condition of trade as they found it.

Mr. Glover: "We are in much better condition than at this time last year, and the prospects are good."

Mr.Marsh: "We are busier, but there's no improvement in prices. Our business is car castings, and pressed steel fittings interfere considerably with cast iron work nowadays."

Mr. Stirling: "We are finding trade better than heretofore, and everything points to a busy summer, but prices are not as high as they might be."

Mr. Pessano: "We are busy, with plenty of orders. It is also encouraging to find that prices are no lower; they are standing still at present, and we hope they will go forward from this time."

Mr. Farquhar, of York: "We do very little foundry work, and that only for ourselves. Our prices are not going down."

Mr. Flagg: "We are in excellent shape. Instead of 36 or 40 molders this time last year, we now employ 70, and we are working at night."

Mr. Ellicott: "The Southwark foundry's condition is 100 per cent better than last year. We are employing 54 molders and are as busy as we can be. We have good prospects and the outlook is very encouraging."

President Wanner: "I am very much pleased with the reports submitted to-night. They are the most favorable we have heard in two or three years. As to the pipe foundry business, it is in pretty bad shape, but the pipe trade is not brisk as a rule at this season of the year."

Mr. Davis, of Thomas Devlin & Co., then read the following paper, by Alexander Cairns, of Chicago, on

"ANNEALING MALLEABLE CAST IRON CASTINGS."

Castings to be annealed are cleaned in the tumbler, pickled, sand-blasted or not cleaned at all, depending on the shop practice. Small castings, such as saddlery and carriage hardware, agricultural and similar classes of work are annealed satisfactorily with the sand on them. Large castings are milled or cleaned in the tumblers, as a rule, although if packed without cleaning will require re-annealing.

Annealing Furnaces.—The furnaces used to anneal are rectangular in section, about 10 feet wide and 18 feet long and 8 feet high in the center of the arch. The fireplace is set on the inside in one corner of the oven and is usually the dimensions of the grate surface, 2 feet 6 inches by 6 feet, extending upward to within 8 inches of the roof of the furnace. The flues extend along each side, on a level with the floor, the whole length of it, and should be about $4\frac{1}{2}$ inches by 9 inches so that a stock fire brick will just fit them. It often happens that a furnace which is one of a number entering the same stack, will not work according to calculations. In this case the flues are stopped up or left open until the furnace has been found to work right. Various forms of doors are used for these furnaces, that in which the brick are set into a permanent sling being the most common.

Annealing Pots.—Malleable cast iron castings are annealed in rectangular sectioned castings called pots, which are set upon a bottom and built four or five high, making one continuous pot from the bottom up. According to the character of the work the continuous pots are divided by setting plates between each of the sections so as to keep the castings separate. They vary in size from 12 inches wide, 24 inches long, 18 inches deep and ½ inch thick for light castings, to 30 inches wide, 72 inches long, 18 inches deep and 1½ inches thick for the larger jobbing and railroad castings.

At times it is advisable to make special sections in the round, square and triangular shapes, when the order on the particular casting will warrant the expense. Such castings for which there are no pots and for which it is not advisable to make them, are bricked up in the furnace with fire brick and firmly bedded in and covered with packing. The bottom plates are made the same size as the pots and from 2 to 3 inches thick and sufficiently high to admit of easy handling with the truck. The pot sections are molded in green sand, cast from the cupola, do not become annealed in use and will last from 15 to 18 heats. In order to secure the best service from them, it is necessary that a fairly good quality of iron be used.

Packing.—Packing is a shop term applied to the class of materials used to pack the castings so they will retain their shape when hot. It is also applied to the materials which answer the above purpose and in addition supply oxygen or have the latter in their composition. There are a number of different materials used for the former purpose which are used principally on light castings; most anything that will stand up well while hot is suitable. Ground, burned fire brick, iron borings and sand are used. As they of themselves are not agencies of oxygen, it is necessary in using them that oxygen be obtained by means of a coating of rust or oxide upon the castings either before or after charging the pots. In rusting them before, much of the oxide becomes rubbed off in packing. Packing the castings wet would do, provided there was some certainty of their being oxidized before heat-

ing. Wetting the packing with dilute ammonia is a very sure means, and in the absence of anything better than ammonia is the most satisfactory way of handling this material.

The use of this class of packing has evidently been confounded by Mr. Davis in a former paper, with the process described by Forquignon, with which it has no relation, but is rather the Reaumer process, with the source of oxygen formed on the castings by oxidizing them, instead of the packing furnishing the oxygen. Of the latter class of packing, forge scale and hematite ore are used. I am familiar with the former only. It is an iron oxide and becomes more desirable as a packing the longer it is used, for the reason of its finer division and consequently lying closer to the casting. In using this packing on castings cleaned or those having the sand upon them, no effort toward forming an oxide upon the castings is necessary, although the formation of such oxide saves the packing; that is to say, less of the oxygen in the packing is consumed. New or green packing is worked in gradually on the heavier work.

Charging the Pots.—Packing or charing castings in the pots, so they will retain their shape, and not scale or hang while hot, is a process that cannot be well described. In general they should be packed with a view to keeping the packing in close contact with the castings during the settling of the contents of the pot. For instance, flat plates or sections should be packed on edge; if on the side, they will scale on the bottom from which the packing has settled. This explains why some castings scale and others do not, in the same pot. Castings that can be stacked on top of each other having projections or unequal sides are built up from the bottom plate, with a view to balancing the pile. All long sections or castings, if not packed in pots that will admit of placing them horizontally, should be set upon the bottom plate vertically. I have seen castings 5 feet long ¾ inches longer than the pattern, due to being packed some inches above the bottom plate and hung in the pot during settling.

As a general rule, there is a relation between the amount of the packing and the castings, or between the oxygen in the packing and the carbon in the casting. There can be a condition,

therefore, where there is not sufficient packing between the castings to anneal. This rule is faithfully carried out with the excess in favor of the packing. The packing of the castings is carried upward, with a view to meeting the unequal heating of the pots; that is, heavy castings in the top and light ones in the bottom, separated by plates when the occasion requires it.

Beginning with the bottom plate, the first pot is usually a new one. They do not take the heat readily on account of the sand upon them, and for this reason should be broken in on top, but owing to their weight it is not practical to use them there. Building or packing continues upward, the pots being placed according to their age, all of them passing out of service as top pots.

The matter of packing castings is attended with many difficulties which materially add to their cost, and which can only be overcome by long experience and observation. The writer has been perfecting a method of annealing castings, on which patents are contemplated, without packing them, which will apply in particular to that class of complicated shapes on which the handling and labor of packing and straightening constitute an important item.

Annealing.—The pots, some 55 to 65 in all, holding from 20 to 22 tons of castings, are set into the furnace with about their bulk between them and its walls. Those containing the heavier castings are placed in the center. The furnace is closed up and firing continued for three days, the door removed and the pots taken out; or, they may be allowed to stand for some time, depending upon what the labor engaged in handling them may be doing.

Under ordinary conditions the first 24 hours' firing shows the pot a red heat. The next day they are at a yellow heat, and the third day they are a bright yellow and can be readily distinguished in the furnace. Firing on the last day stops with the disappearance of carbonic oxide flame. There is no regular length of time for this flame to burn. It depends on the relative proportions of castings to packing or carbon to oxygen. Its disappearance usually is not an indication that thorough annealing has taken place, al-

though it may be, but is rather an evidence that the oxygen in the packing immediately adjacent to the casting has been consumed, spent or used up.

If it were possible to raise the pots to the necessary temperature in 12 hours, annealing would take place just the same. Experiments that accomplished this, but were made with a view to saving the fuel used in the furnaces, were made some years ago in New York State. The pots were set into the flue of the furnace, and as there was no satisfactory way of controlling the temperature at that time, annealing by this means was discontinued. Small or medium-sized castings can be annealed in a few hours by packing in a hand ladle, removing a few brick from the side of the furnace and setting in on top of one of the pots with a pair of tongs.

Large lots of castings are annealed in from one and one-half to two days by selecting the furnace nearest the stack and enlarging the flue area, i. e., taking out a few brick with which some of the flues had been stopped. If the pots are five sections high, the top section only is packed, the lower one being empty, having plates set in between them so as to raise the top pots, as near the roof of the furnaces as practical. As soon as annealing is indicated the firing should slack off and the pots be allowed to soak until the flame has disappeared.

The manufacture of malleable castings without annealing has received much attention from practical men in the business, and one direct result of experiment in this line has been the discovery of a mixture, 1½ per cent of which renders the castings workable to some extent, but they are in no sense malleable. This class of iron has been used in steel ranges and castings wanted in a hurry.

On the whole, the process of annealing is a very simple one, and there are many apparently mysterious happenings that are due to quite simple causes. Owing to the variations in the working of the furnace a heat is occasionally burned in the top pots. This is a matter of firing and is not common in old furnaces that have been experimented with until found to work right, but cannot be avoided entirely in new ones. Heats are often with-

drawn and found to be not annealed. This is an evidence that the furnace was not hot enough and that it was not properly watched. Heats of this kind are returned to the furnace and fired over.

At the conclusion of Mr. Cairns' paper, Mr. Davis made the following comment upon it: "The process described by Mr. Cairns, which he thinks I have confused with that described by Forquignon, calls for a little comment. The only reference I made to sal ammoniac was the use of a weak solution on the spent packing, as oxidation of the ferrous oxide proceeds more rapidly if this substance be used. The description that Mr. Cairns gives of annealing a rusted casting in sand, and assuming that the oxygen of the rust oxidizes the carbon is, I believe, based on a wrong theory; that is, so far as concerns actual practice. It is true that Reaumer was led to the discovery of the process which bears his name by noticing that a cast iron plate which had been exposed to the direct action of the fire for a long time while covered thick with oxide on the outside, was soft inside; but I think nobody will contend that this is a practical means of producing merchantable castings. It has been shown (Royston, Journal of the Iron and Steel Institute, 1897) that the oxidation which takes place when annealing in sand is due to the diffusion of the air through the charge. As there is a thin film of iron oxide on annealed castings, it is possible that this oxide has acted as a carrier of oxygen; or, to put it in other words, the oxygen of the air rusting the surface of the casting which is in turn reduced, as the carbon diffuses, and so on, making a continuous operation. It should be noted that if the air had nothing to do with the oxidation, as claimed by Mr. Cairns, the thin film of rust on the outside of the casting could furnish but a very small amount of oxygen, and we should expect little less of carbon. As a matter of fact, annealing in sand in open pots showed a diminution of carbon from 3.88 per cent to 2.50 per cent in bars $\frac{3}{8}$ inches thick (Journal I. and S. I., 1897, p. 160). To account for this loss on the theory given by Mr. Cairns, let us assume the rust on the castings is all ferric oxide, which was completely reduced afterwards. I

estimate that over 4 per cent of the iron of the casting would have to be rusted to furnish the necessary oxygen.

"The use of the word anneal in reference to malleable castings leads to much confusion, and I have often wished a more explicit term were used. Webster defines 'anneal' as 'to heat and cool slowly for the purpose of rendering less brittle.' If this were all that was accomplished, there would be no need of another term, but the process also includes a partial oxidation of the silicon (changing the combined carbon to graphitic temper carbon), a variable oxidation and removal of the carbon. As the word anneal is commonly used by malleable founders to mean any or all of these, it certainly leaves something to be desired in point of clearness.

PROCEEDINGS OF THE WESTERN FOUNDRYMEN'S ASSOCIATION.

The regular monthly meeting of the Western Foundrymen's Association was held March 16th, 1898, at the Great Northern Hotel, Chicago, with the president in the chair.

This meeting was devoted chiefly to a discussion of the paper contributed by M. McDowell to the January meeting. [This paper is printed in the A. F. A. Journal for February.—Ed.]

Mr. Thos. D. West sent the following communication: As you invite a discussion on the paper, I wish to enter a protest against the claim that it is essential in analyses of pig irons to include the carbon with the other metalloids. This view was taken at your last meeting, as well as on several other occasions, by men well up in the chemistry of iron. I believe that in foundry pig iron, carbon can generally be wholly ignored. The state of the carbon, whether graphitic or combined, in any brand of pig metal, is chiefly regulated by the rate of cooling as it is cast at the blast furnace. Suppose a blast furnace when tapped had its stream directed to two different channels, one leading to the ordinary sand bed and the other to "chills," or iron molds. Analyses would show the carbon in the chilled or sandless pig to be largely combined, while in the sand pig, the graphitic would be in excess of the combined carbon. If we are to be guided by the carbons, the chilled or sandless pig would be graded as an iron to make hard castings, while the sand pig metal would be set aside for soft castings. The fact is that the chilled pig would give, if anything, a softer casting than the sand pig, as I showed in the paper at your meeting at Cincinnati last October. Of course this illustration is the extreme of what may be expected in the carbons of pig iron, coming from one "cast." Nevertheless, pig irons of the same grade, cast in sand, from one or more "casts," vary widely in their carbons, due to the variations in the fluidity of the metal as it comes from a furnace, and its rate of cooling in the sand beds, also to differences in the size of the pigs. What is necessary is a knowledge of the silicon, sulphur, phosphorus and manganese

contents of the pig metal. The different percentages of these four elements, as a rule, regulate grades in pig iron, where we are guided by analyses; and the carbon can be almost wholly combined or graphitic and still be ignored, as intimated above, in calculating foundry mixtures.

If it were true that the carbons could indicate the true grade of pig metal, then all claims of our inability to define correctly the grade of pig iron by its fracture, and of the great value of analyses in making mixtures of iron, are fallacies. Few realize the plight founding is in at the present day. Here we are educated, of late, to know that we cannot tell the grade of pig metal by its fracture, and that chemistry is our best guide to grade pig iron before it is remelted; still, for all this, there are those who through self-interest try to suppress chemistry, or regard with indifference restrictions and practices by which analysis would become a positive guide in making mixtures.

Mr. Sorge: Mr. West states that carbon can be ignored in the analysis of pig iron. He says further: "If it were true that the carbons could tell us the true grade of pig metal," etc. The claim has not been made that the condition of the carbon in the pig metal is a true guide to its character, but that the total amount of carbon in that metal will affect the character of the castings that are produced. In other words, the larger the amount, the greater the influence of the different metalloids on that carbon. Now if you omit carbon from the series of elements to be ascertained in pig iron, you are omitting the element which really makes pig iron and really makes cast iron; the fact being that carbon contained in iron produces the cast iron, while the various metalloids are simply the agents in influencing the condition of that carbon. And the amount of carbon actually contained in the iron is as important to know as it is to know the amount of these various metalloids or metals that influence its condition. As an illustration: In the manufacture of malleable castings it has formerly been held that the malleableizing of iron was due to decarbonization. The facts that have developed in the last few years have shown that this is a fallacy. And it has further been found by the manufacturers of malleable iron that very rich carbon irons are

the very best irons to be employed in the manufacture of malleable castings. There are now some furnaces that are manufacturing iron, in which the total amount of carbon contained goes up as high as 4.3 per cent, which is something unusual in the way of ordinary pig metals. And this iron, a coke iron, by the way, is one of the very best metals that can be employed in the manufacture of malleable castings. This shows that the amount of carbon contained in the iron is as influential in the grading of iron, or in varying the quality of the iron for the purpose for which it is to be used, as the different amounts of these metalloids or metals to which Mr. West calls attention, for influencing the condition of this carbon in the iron.

Maj. McDowell: I think that Mr. West has got the thing confused. There is a difference between the value of pig metal and the value of the fracture to indicate what that iron is. There is no question that, if you are going to grade by the fracture the amount of carbon in the iron doesn't cut any figure at all, but when you come to buy the pig iron the amount of carbon does cut a good deal of a figure, because carbon is the life of iron. Malleable castings are to be made out of the very hottest metal that can be made, and carbon is what carries the life, and so we put the iron in the furnace to desiliconize it, and in doing so raise the heat. But if there isn't carbon there it won't carry it, and so it is that iron that has the largest amount of carbon in it is the most desirable for making malleable castings. It doesn't follow because that is so that that is going to show anything in the gradation of iron by fracture. It doesn't make a particle of difference whether the iron is cast in the sand or cast in the mold. It will affect the fracture, but it will not affect the chemical constituents of that iron.

Each of us has had his attention more or less attracted to the subject of the practical value of the metals and the metalloids that combine with iron in making castings and also give the value of pig iron to the foundryman. Which of these elements has the most to do with determining the value of pig iron? Is it possible for the foundryman to formulate a specification by which he can

order or contract for the metal that will meet his special requirements? As a general thing the furnaceman or his sales agent has his various brands, as Iroquois, Sterling Scotch, Peerless, Nos. 1 and 2 soft, silver and silver gray, and Nos. 1, 2, 3, 4 foundry, gray foundry, foundry forge, white forge, Bessemer and off-Bessemer, malleable pig and charcoal pig. Some of these names do designate a special purpose for which these metals are well adapted, but the majority of them have no significance to the foundryman. And what is No. 1 or 2 soft, or Nos. 1, 2 and 3 foundry to one furnace has no application to another. The names and numbers here have no significance except just to the sales agent who transposes them to suit his customer.

Is there not enough of homogeneity among the many foundrymen's associations to enable them to formulate a gradation of foundry pig by which they can contract for their metals? To illustrate, I have a tabulated statement, as follows:

No.	Kind of Iron.	Silicon.	Phos.	Mang.	Sulphur.	Price per ton.
1	Foundry Pig.	2.75 to 3.00	20 to .50	40 to .80	.025 to .050	$11.75 to $12.00
2	Foundry Pig.	2.50 to 2.75	20 to .50	40 to .80	.025 to .050	11.50 to 11.75
3	Foundry Pig.	2.25 to 2.50	20 to .50	40 to .80	.025 to .050	11.25 to 11.50
4	Foundry Pig.	2.00 to 2.25	20 to .50	40 to .80	.025 to .050	11.00 to 11.25
5	Foundry Pig.	1.75 to 2.00	20 to .50	40 to .80	.025 to .050	10.75 to 11.00
6	Foundry Pig.	1.50 to 1.75	20 to .50	40 to .80	.025 to .050	10.50 to 10.75
7	Foundry Pig.	1.25 to 1.50	20 to .50	40 to .80	.025 to .050	10.25 to 10.50
8	Foundry Pig.	1.00 to 1.25	20 to .50	40 to .80	.025 to .050	10.00 to 10.25
9	Foundry Pig.	.75 to 1.00	20 to .50	40 to .80	.025 to .050	9.75 to 10.00

The price per ton is an assumption on my part. This table shows the variation only in the silicon, as it is this element that influences the value of metals. As each number varies 25 points in silicon, so does the price per ton vary 25 cents per ton, making each point of silicon worth one cent. As phosphorus and manganese are made to appear uniform, the former varying from .25 to .50 while the latter varies from .40 to .80, these variations are admissible and would not affect the price of the metal, but it would influence a preference, depending upon the special nature of the casting to be made. Sulphur is quite different and has nothing in it that is good at all in making castings for any kind, although I know of some who advocate its use in making chills. In chilled iron it makes white iron, but there is no advantage in

the chills. As one atom of sulphur is supposed to neutralize 10 of silicon, and if this is so then sulphur is an element to be considered in a scale of prices when the amount of silicon determines the value of the metal. How good this claim is that one atom of sulphur neutralizes 10 of silicon, I am not fully prepared to say, but I do know that when sulphur is above .05 and silicon running low in your castings the claim holds good, and as a precaution I would suggest when sulphur runs over .05 in the pig, say .075, it should make a difference in the value of the pig iron of 25 cents per ton. Say, for instance, it is No. 4 in my list, which in the table shows 2. to 2.25 silicon and .05 sulphur, and is worth $11 to $11.25, but if the sulphur runs as high as .07 it would be worth $10.75 to $11.

With these thoughts and suggestions, don't you think it worthy of our effort, the effort of this association, to inaugurate a proposition for the united action of all the foundrymen's associations, looking towards a more intelligent way of classifying or grading pig iron?

Mr. Sorge: I would like, in discussion of Maj. McDowell's paper, to call attention to the fact that he also makes the error of not paying sufficient attention to carbon contents of the iron. It is the most vital thing in the iron, the absolutely vital thing. Maj. McDowell made the statement that the carbon carried the heat. I think a little better explanation of that would be that the higher the carbon contents of an iron, the greater its fluidity; it doesn't carry the heat, but it will melt at a somewhat lower temperature than iron with a small amount of carbon in it, and therefore will hold its fluidity longer than an iron which is poor in carbon. Furthermore, in malleableization, the effect of high carbon seems to be an easy separation of the carbon from the iron during the process of annealing. The iron seems to be more easily annealed with high carbon than with low carbon contents. Now the effect of carbon of gray iron is known to all of us, that is, the higher amount of carbon the finer we can make our castings, into the finer grooves can we run that iron, the longer will it hold its heat, the fact being it is more fluid, and the iron is in every way a more

valuable iron, except for special purposes, those in which we want to produce an iron having very small carbon contents. Therefore I think that the matter of the carbon contents of the iron should be given more careful consideration in the grading than the Major proposes here, and I think it is a subject that will be of great value to the foundrymen in general if taken up intelligently by the various foundrymen's associations of the country and by the furnacemen. If united action could be taken to establish a uniform grade which shall be standard and accepted by them it would be of vast benefit to the trade in general. I trust that the Western Foundrymen's Association, as usual, will take the first step in the direction of this advance for the foundry trade.

Maj. McDowell: My talk was simply to bring before the association the thought that I had, for I see wherever I go, a confused condition of things in regard to the selling of pig iron. A man calls upon me about his pig iron and talks to me about the graphitic carbon, and another one will talk about another thing. They call it No. 1 soft, and I don't understand what they mean by it. It does not convey any idea at all to me when he says, "This is Peerless," or, "this is something else." What the foundryman wants to know is, what is the iron? What is it made up of? And I simply have formulated this thing to bring out just what Mr. Sorge has suggested. I think it is high time that some association, and this has been rather the leading one in the country so far as ideas are concerned, ask that the foundrymen's associations go to work in formulating some gradation of pig iron that will give a more intelligent way, so far as the foundryman is concerned, of buying his metal. I haven't the slightest objection to including the furnacemen; but I think that they would rather be left out. The more confused it is between the foundrymen and them, the better it is, for they have the iron to sell; and I have often said that the less a man knows about iron the more he can sell. Still I wish someone would formulate some sort of a resolution that would put this thing in shape as Mr. Sorge has suggested.

Mr. Sorge: I would like to take issue with the Major on the question of leaving out the furnacemen. I don't think we want the pig iron salesmen in, but we do want the furnacemen; because when we have practical questions of melting, to produce iron of a certain grade, as shown by the paper presented by Major McDowell, the question will come up, whether they can produce iron that has these definite contents, or close to these definite contents of the various metals and metalloids. And in order to bring grading to a point where it shall be of practical utility we must furnish the furnaceman with specifications of what we want, of such a character that he can produce it. We must not furnish him with something that is going to give him an immense amount of trouble to produce, therefore he must be called in to advise on the subject of grading. And I would move that the Western Foundrymen's Association appoint a committee of three to communicate with the other foundrymen's associations of the United States and Canada, and to formulate a plan by which concerted action can be taken for grading pig iron in an intelligent manner, that shall be comprehensible to all furnacemen and to foundrymen.

Mr. Ferguson: I second that motion; yet it seems to me that it is asking a good deal not only of the foundrymen's associations, but of the furnacemen. I think the first step in that direction is for the foundrymen to educate themselves to know what they want before they ask the furnacemen to furnish them with the iron. I don't think we would be any better off to-day if the furnacemen were in a position to furnish anything that is required. I don't believe the furnacemen of this country are able to dictate their requirements, and I think the thing first to do is to school the foundrymen to know the requirements, then ask the furnacemen to supply them.

Mr. Sorge: I made the motion in the shape in which I did with some object of that kind in view. The idea that I meant to convey was that the committee should be appointed to formulate, if possible, a plan under which they could work. Now if that committee comes to the conclusion that such a plan can

not be formulated in a practical way it is for them to report back to the association that that is their decision, and their reasons why they have come to that decision. We will then be able to determine what it is that is lacking in order to get the foundry trade in a condition in which foundrymen can say to the furnacemen, we want black or we want blue or we want gray. To-day we tell them, "I want something," and I think it is time we made a move in the direction of defining our position in that matter.

Mr. Ferguson: This discussion is leading on to just my idea of what it ought to be, schooling and educating as we go along. Maj. McDowell has stated to-night that the value of iron is based upon its silicon contents. I was just thinking that that doesn't match with the prices that have been submitted to me of late. Charcoal irons as a rule run low in silicon—below 2 per cent; to-day, even with the demoralized state of the charcoal market, it is higher in price than any of the coke irons. Then Mr. West in his statements wants us to ignore carbon in iron, and makes comparisons. These things are all in the direction of educating and schooling, and are preliminary and right. I don't agree with Mr. West. I think that we must look after the carbon in iron. I know of instances myself where the value of castings has been determined by the amount of combined carbon. You are there to watch it and gauge it and know its relative value, and you can't get along without watching the carbons as well as the other elements that are in the iron. And I still think that this paper on the value of the metalloids is just beginning to wake up the foundrymen. But I think it is a little premature to ask the furnacemen to supply us with something when we don't know what we want. Let the foundryman first know his requirements, then insist that the furnacemen shall supply them.

Maj. McDowell: There is no question about the condition of the foundrymen to-day. When a manufacturer of castings sends out a specification to furnacemen with a request that they furnish prices on pig iron, he will refer to castings of a certain grade, and the furnaceman has got to turn in and be a foundryman. Now that is all wrong. There are a few foundrymen to-

day who make specifications of the kind of iron they want for their castings. They know what will make them, and they are very careful that they get what they contract for, too. It is a matter of course that it will take some time for the balance to get to this point, but there is no reason why we shouldn't commence on this line. Now, I leave out carbon because carbon doesn't regulate the price of iron. It regulates the value in special cases. I say nothing about manganese or phosphorus; they regulate the value of a certain grade of pig metal to a man for special castings. It is a fact that to-day iron is bought and sold on account of its silicon contents, less the effect that the sulphur will have on it. I don't go back at all upon the value of carbon or manganese, or the value of phosphorus—all these for special purposes—but I am speaking about gradation of metal. We grade it, and silicon is the thing that regulates the value of pig metal to the foundryman because it will carry more or less scrap. Carbon gives heat and fluidity by adding silicon to the iron. But when a man gives you a list of metals, the first thing you look at is silicon, and the sulphur next. Then the question is, where is your manganese; and if you are in a certain grade of castings, where is your phosphorus? All those things follow as a matter of course; it depends altogether upon what the castings are. A man will give the preference to the pig iron that has that element in it that he specially wants, but the value of the pig metal is entirely regulated by the amount of silicon in it, and that is a good standard. There isn't anything that will so educate the foundrymen as to have them work over that proposition; and I think some foundrymen could afford to spend some money in that direction to know what sort of pig metal they want for their castings. I would like to see a unanimous vote of this association that we have this committee.

Mr. Sorge: Maj. McDowell starts out on the basis that the value of pig iron to-day is determined by its silicon contents, and therefore we should make our gradation of iron by the silicon contents. Now I claim that anything that affects the iron for the purposes of the foundryman should be taken into consideration in making up the grade. The carrying of scrap

is an exceedingly valuable element in a pig iron purchase. There are other elements that enter into it, as Maj. McDowell admits; but he brushes them aside as being simply for special purposes, and are not necessarily to be considered in the general grading of the pig iron. I claim that in the general grading of pig iron the total characteristics of that iron as developed by its analysis ought to be considered. Take the case of the modern charcoal furnaces that are being built, 20 to 30 feet higher than the old furnaces, with one principal purpose in view, and that is to raise the carbon contents of the iron, for the irons richer in carbon are worth quite a little more money than the poor carbon irons and will continue to be.

Mr. Ferguson: This last week I looked over the analyses of probably 50 different brands of pig iron, our firm contemplated purchasing, and I think in that assortment a man could pick out anything that he wanted, as long as he knew what he wanted; it is there, it is on the market. I don't know how they could get it different from what they do grade it; but you can get any kind of iron that your requirements call for. And I don't see myself how they can be called upon to supply something to fill the requirements of everybody when they don't know what those requirements are. I think the thing to do first of all is to school men and educate them to know the requirements.

Mr. Sorge: I think that perhaps Mr. Ferguson is a little bit misled by not considering that to-day the grading of iron of course is by fracture. Bear that in mind, that the idea is to get rid of that grading, which we consider unreliable, and to substitute for that a grading which shall give certain standards to which the furnacemen and the foundrymen can refer in attempting to make purchases of iron. To-day, if you go to purchase a No. 2 soft iron, you may get one thing from one man and another thing from another man. Now the idea is to so define what a No. 2 iron shall be, that it shall convey a distinct and definite idea to any man who purchases it. That is as I understand the whole sum and substance of this committee's work, and to obtain such a standard to be adopted by the various foundrymen's

associations, and then to be adopted by the furnacemen as being considered practical, as giving grades that they can distinctly recognize and can manufacture. To-day we haven't a grade that can be distinctly recognized by two individuals as the same thing.

Mr. Ferguson: That would be a happy state of affairs if we could ever get it. I believe the thing is working that way itself, and I believe it will continue to work out that way if it is left just as it is. The fact is that there are many furnaces now that will give you a guaranteed analysis of their iron right along, and those that are looking for iron with a guaranteed analysis will patronize those furnaces that are willing to furnish it; and that will bring other furnaces into line and they will analyze their iron and sell it by analysis instead of by fracture. One man's requirements are different from another man's requirements, or he thinks they are, anyway; what suits one won't suit another.

Maj. McDowell: Every furnaceman has a name and number for his pig metal, that don't correspond with any other furnace at all, and as long as that is so it is unsatisfactory. Why not have all the furnacemen agree upon what shall be No. 1 and what shall be No. 2? We will say, for instance, the base price from this table that I have given here is No. 5, on each side of it are so many numbers; No. 5 is two per cent silicon. Now the foundryman says the pig iron to-day is worth $10; he means that base and all the others grade up from it just 25 cents.

PROCEEDINGS OF THE PITTSBURG FOUNDRYMEN'S ASSOCIATION.

At the meeting of this association, held March 28, the following paper was read by Charles W. Friend, of the Clinton Iron & Steel Co. His subject was,

"A FEW FACTS NOTED IN MANUFACTURING FOUNDRY IRON."

It gives me pleasure to read before you this evening a paper in which I try to set forth a few facts about foundry iron as seen from a manufacturer's standpoint.

I know from experience that a blast furnaceman is looked upon by foundrymen as little better than a robber, whose sole object is to get rid of his product, whether good or bad, without regard to how the iron will work for the poor foundry that receives it. Now, gentlemen, this is not so. The manufacturer today is trying his best to give the foundryman the best iron he can for his particular purpose. With this idea in view, manufacturers have employed chemists, and the more advanced furnaces have quit the old, haphazard practice of piling all iron together which happens to grade as No. 1, No. 2, No. 3, etc., when the chances are that the No. 1 is the hardest of the lot, and only fit to make rolling mill castings, while No. 2 or No. 3 is an ideal iron for making snap-flask work.

But, in many instances, the foundryman in buying his iron misrepresents facts to his own detriment. For example, a salesman goes to sell Mr. Brown, who is running a foundry (of course not in Pittsburg or vicinity) a car of iron. He tells him how soft his iron is, how much scrap it will carry, and all its good qualities. The price is satisfactory and Mr. Brown buys. The salesman asks him what kind of castings he makes, and how much scrap he wants to use. Now, Mr. Brown will not trust the manufacturer. He wants a soft iron to carry 20 or 30 per cent of scrap and make good machine castings, but thinking he will get something extra soft, he tells the salesman he is going to use 60 per cent scrap, and makes small castings. The order comes in to the furnace, and iron is shipped, containing 3.70 or 3.80 per cent of graphitic carbon, which Mr. Brown tries to work with his 30 per

cent good scrap, and the result is that his castings are so dirty and full of blow holes that they are a total loss; whereas, if he had told the salesman the truth, and trusted the manufacturer, an iron of the proper analysis would have been shipped him, his castings would probably have been just what he wanted, and the furnaceman would not have lost Mr. Brown's trade.

Another thing which makers of foundry iron have to contend with is high sulphur coke, which sometimes will get into the best iron foundries. This coke looks all right, is from the same parties from whom the last lot was bought, and the foundryman knows nothing about it until his castings begin to come hard, and his shrinkage is away above what it should be. He is in trouble, and the first thing he does is to blame the iron. He may have three or four different brands in his mixture and, of course, he blames the iron which has the closest grain and looks hard, when the chances are that this is the softest iron in his mixture. He keeps changing his iron around with no better results until, in despair, he sends samples of his iron, castings, scrap, etc., to the furnaceman. These are analyzed. The castings are found high in sulphur, while the iron and scrap are all right; therefore the trouble must be with the coke. This is analyzed, the sulphur found, new coke used, and the foundryman gets good results.

As I said before, the foundrymen's practice of judging iron by the fracture often causes a great deal of trouble. It is easy for the furnace to make a No. 1 iron with 2¾ per cent silicon and .040 per cent sulphur, but it is a different matter to make open iron with 2¾ per cent silicon and .012 sulphur. To make low sulphur iron it is necessary to use a large amount of limestone in the ore mixture which takes the silicon as well as the sulphur out of the iron; and to get high silicon iron under these conditions it is necessary to work a blast furnace very hot. This requires more coke and closes up the grain of the iron. But tests which we have made time and again show that the low sulphur iron is by far the softer of the two. But what furnace is going to use more coke and more limestone per ton of iron produced and then make an iron which, although better, is not salable to many foundries?

This idea of close iron always being hard probably comes from the fact that in past years the old-fashioned blast furnace very seldom made iron which was close from being made at too

high a temperature, but often made close iron with low silicon and very high sulphur, due to the furnace working too cold and irregular. This kind of iron would, of course, be hard and have great shrinkage.

Following is a series of tests which were made with the idea of determining iron of suitable analyses for various kinds of work. These tests were made by charging 1,000 pounds of pig iron in a regular 24-inch cupola operated as in the regular foundry practice. The iron was run into strips ⅛ inch and 3-32 inch thick, the ⅛-inch strips being 2½ inches wide and 24 inches long, the 3-32

TABLE A—PURE PIG IRON.

	No 1.	No 2.	No 3.	No 4.	No 5.	No 6.	No 7.	No 8.	No 9.	No 10.
Silicon	1.15	1.50	1.60	1.80	2.00	2.25	2.50	2.60	2.80	3.00
Sulphur	.010	.012	.014	.016	.018	.016	.020	.024	.020	.022
Phosphorus ..	.60	.56	.58	.61	.55	.54	.61	.60	.51	.60
Manganese ...	.50	.52	.49	.45	.90	.50	.70	.45	.80	.35
Graph. Car...	3.60	3.10	3.20	3.40	3.0	3.70	3.30	3.80	3.50	3.70
Comb. Car....	.12	.35	.30	.25	.14	.12	.18	.16	.20	.06
Tensile Str...	16,000	19,000	15,000	24,000	18,000	17,000	18,000	16,000	15,500	14,500
Trans. Str.....	1,800	2,100	1,700	3,000	1,600	1,700	2,000	1,500	1,600	1,400
Fluid.....	Flu.	Flu.	Flu.	Flu.	Flu.	Flu.	Flu.	Flu.	Flu.	Flu.
Soft.....	Soft.	Med.	Soft	Hard.	Med.	Soft.	Soft.	Soft.	Med.	Soft.

TABLE B.

Same iron with 30 per cent. good machinery scrap.

	No 1.	No 2.	No 3.	No 4.	No 5.	No 6.	No 7.	No 8.	No 9.	No 10.
Softness.....	Soft.	Med.	Soft.	Hard.	Hard.	Soft.	Med.	Soft.	Med.	Soft.
Fluidity.....	Flu'd	Flu'd	Flu'd	Flu'd	Flu'd	Flu'd	Soft.	Flu'd	Flu'd	Flu'd

TABLE C.

Same iron with 60 per cent. good machinery scrap.

	No 1.	No 2.	No 3.	No 4.	No 5.	No 6.	No 7.	No 8.	No 9.	No 10.
Softness.....	Hard.	Hard.	Med.	Hard.	Hard.	Soft.	Soft.	Soft.	Med.	Soft.
Fluidity.....	Flu'd	Flu'd	Flu'd	Flu'd	Flu'd	Flu'd	Flu'd	Flu'd	Flu'd	Flu'd

inch strips being 2 inches wide and 20 inches long, gated at one end and poured while in a horizontal position. By this means the relative fluidity and softness were determined. The tensile strength and traverse strength were determined by bars of standard cross section cast in pairs from one gate. All tests were made by the same set of men so as to get the personal factor as nearly uniform as possible. In the following tables where the word "soft" is used it is understood that all the strips were easily filed at the extreme end from the gate. "Medium" means that the ⅛-inch strips were soft and the 3-32-inch strips hard. "Hard" means that all strips were hard. Under "Fluidity," "fluid" means all strips were fluid. "Medium" means the ⅛-inch strips ran out

while the 3-32-inch strips did not run out full. These particular tests were selected on account of the silicon analyses.

Note that test No. 1, Table A, with silicon 1.15 per cent, was both soft and fluid. This is due to the high graphitic carbon and low combined carbon. Other tests made with low silicon, low graphitic carbon and high combined carbon being fluid, but hard. As seen in Tables B and C, this iron was soft with 30 per cent scrap, but hard with 60 per cent. Test No. 2, with 1.50 silicon, illustrates the effect of high combined carbon with low graphitic carbon. No. 4 shows high tensile and traverse strength. No. 5 shows the effect of high manganese, also the comparatively low graphitic carbon lessens its value as a scrap carrier. It would be interesting to see how much scrap an iron like No. 10 would carry. In fracture this iron was light colored and very close grained. The test bars and strips were uniform, close gray castings, with no apparent difference between that with 30 per cent scrap and 60 per cent scrap.

To sum up these tests, it might be said, to obtain a soft iron on a basis of 1.50 per cent silicon, the sulphur must be very low, the graphitic carbon high and the combined carbon low. As the silicon increases, the sulphur may increase slightly without noticeable result. For scrap carrying purposes the graphitic carbon should be high, with enough silicon to keep the carbon in that state. The sulphur should be as low as possible, for it should be remembered that under ordinary conditions the oftener iron is melted with coke the more sulphur it takes up. For fluidity we must look to the phosphorus, for to this element more than any other fluidity is due, and as the silicon increases so must the phosphorus, to obtain the same fluidity.

At one time, after the furnace was coked down on a Bessemer mixture, we made, in starting, iron containing 8½ per cent silicon and 3.80 per cent graphitic carbon. We were going to put the iron through the furnace again when a foundryman happened along and saw it. He insisted it was just what he wanted, and took away a load to try. It melted all right in the cupola, but was so thick he had trouble pouring it out of the ladle, and, of course, it would not run in his molds. If this iron had contained 1¼ per cent or 1½ per cent phosphorus, it would have been fluid enough to make the finest castings.

A REVIEW OF THE FOUNDRY LITERATURE OF THE MONTH.

IRON AGE.

In its issue of March 10, this journal says of the activity in malleable iron castings:

"Western manufacturers of malleable iron castings have for some time been overrun with orders. The foundries are now reported to be so crowded with work that consumers are finding very great difficulty in getting new business accepted for anything like reasonable delivery. The activity in this trade is largely, if not wholly, due to the heavy output of farm machinery by the implement manufacturers. They are enormous consumers of malleable iron castings, and this year their production of all kinds of farm machinery will considerably surpass that of any previous year. Hence they are exerting a powerful pressure on the malleable castings trade. The inconvenience to which consumers of such castings are being subjected at present appears likely to lead to the establishment of additional foundries. Consumers themselves may put up their own foundries if their consumption of malleables is large enough to warrant such a step, or enough of them are clustered in a locality to make a joint foundry desirable. If this should be done to any extent, and quite a number seem to be contemplating such a step, the inevitable result would be over-capacity of malleable foundries and prices cut below a living basis. Consumers should weigh the chances of a continuance of present conditions very carefully before deciding to build their own malleable foundries. If remunerative prices for farm products were assuredly permanent, the expansion thus contemplated would be fully justified. But as there is no assurance of their indefinite continuance, it might be well to wait a little longer."

The issue of March 24 contains an illustrated description of the Niles Tool Works, Hamilton, O.

The activity among the iron founders is thus commented on:

A most encouraging feature of present business conditions is

the increasing activity of foundrymen. Although every one connected with the iron trade has for a long time been apt to consider his own line as most seriously overdone, yet the foundrymen have perhaps had the hardest struggle to make both ends meet. That they have often not met is shown by numerous vacant jobbing foundries scattered all over the country. But for some months the tide has been rising in this as well as in other branches of the iron business. Foundrymen have learned that they were not wholly forgotten, and their services have been more and more in demand as the country wakened up to general industrial activity. The pipe foundries are not so well employed as they might be, but they are about the only class really suffering for lack of work. On the other hand, the malleable foundries are the most rushed, the demand for malleable castings being unprecedented. The makers of all kinds of specialties are also crowded, while the jobbing foundries everywhere are well employed. For the first time in years a considerable expansion of founders' facilities is being made. Idle foundries are being leased, or additions are being made to old works, while new undertakings are projected.

The foundry is such a universal expression of the iron trade, a more or less pretentious molding shop being found in even the smallest towns, that much significance can safely be attached to the increasing demand for its products. When the little foundries get busy, it means the widespread prevalence of prosperous conditions. Stinting economy has given way to something like generous indulgence. Repairs are being made to machinery, farmers are undertaking improvements, manufacturers and merchants are stocking up more liberally, and the foundryman comes in for his share of the general improvement.

Manufacturers of foundry pig iron have excellent reason to feel hopeful over the reports which they are now receiving from their customers. The demand for such iron has for some time been less than the supply, and prices have, therefore, dropped. But unless the reports are wholly misleading, and the consumption is much below what it is represented to be, the time is near at hand when the output of foundry iron will not more than meet the requirements of the foundry trade.

A contributor writes the following of "The Progress of Open Hearth Cast Steel in Machine Construction:"

The Progress of Open Hearth Cast Steel in Machine Construction.

To even a casual observer in the field of mechanical arts the long stride which cast steel has taken during the past five or six years is very striking and impressive. Indeed, so rapid has been the displacement of other material by this one that apparently there is only the question of cost which prevents its almost universal adoption for everything in the line of machine work except where plate is necessary. Even as it is we have steam cylinders and covers, valves, pistons, eccentrics and rods, bed plates, propeller blades, steam pipe and boiler fittings, driving wheel centers and shaft bearings all made commonly from it, and the question of cost is a drawback only where forged steel can be run into the shapes desired by rolls or the drop forge, and avoid the time and consequent increased cost required to mold and clean up a casting.

The word "apparently" in the above paragraph is, however, used advisedly, for there still remain certain specific limitations, aside from cost, beyond which cast steel can only go by reason of improved methods in foundry practice and a deeper investigation into the causes which render this most useful metal uncertain as to its interior integrity, especially in large castings or where contiguous sections vary greatly in thickness. Thus such parts of an engine as are called upon to bear greatly varying and vibrating stresses are preferably made of the forged and kneaded metal, simply on account of this element of uncertainty, and not at all for any reason of lack of proper qualities of the metal itself.

The general character of open hearth cast steel is now almost perfect as to uniformity, toughness, malleability and tenacity, and there is no longer propriety in associating the word "brittleness" with it, a word which, in no very distant day of the past, was applicable to nearly all cast materials. An open hearth steel casting of to-day can have all the fine physical qualities of a forging. The control of the amount of carbon and manganese and the elimination of the impurities of sulphur and phosphorus are no longer difficult problems. Exactly what is desired in these re-

spects can be procured, so that test bars are common, which will show a tensile strength of 70,000 pounds per square inch of cross section and give at the same time an elongation of 22 per cent and a reduction at the break of 40 per cent of original area, besides bending double, cold, without showing cracks or flaws. Hence it is not a difficulty in obtaining superior physical qualities in the metal that troubles the makers, but rather the penetration of the obscurity which still surrounds the formation of interior defects, blow holes, shrinkage cavities and sand spots within, which give the factor of uncertainty such great weight when important parts are involved. It is to this that greater experimental attention should be given by managers of steel plants. There is too much tendency on their part to be satisfied with the output of such shapes as their experience has led them to be able to perfect, instead of devoting a portion of the profit to solving foundry mysteries and applying remedies which would expand to far greater proportions their industries.

Primarily, there is a fault which certainly can be corrected readily, but to which as yet insufficient attention has been given, and that is the misconception on the part of the pattern makers of the difficulties surrounding casting in steel. These artisans are accustomed to making patterns for the more fluid cast iron, or for the various compositions, and when they come to make a pattern for steel they vary not one iota.

There are few patterns in engine work as generally received which could not be in some degree improved to the betterment of the casting, and it would undoubtedly pay to have patterns made at the steel works, just as it pays to have a good machine shop attached to big foundries. Of course there would have to be superior mechanical or engineering talent to supervise, so that from drawings sent by the engine builders patterns combining the ideas and weights desired could be made with only such departure from the drawing details as would intelligently conquer any difficulties in casting, without interfering with the general plan or location of connections.

Shrinkage cavities are by far the worst defects in a steel casting. They are generally found under the sink heads or risers, yet

they sometimes appear beneath a good surface or are only disclosed by casualty. They approach more nearly to cracks than anything else, as the manner of their formation draws the metal in streaks. This trouble is attempted to be overcome by using great weight of sink heads from which can be fed the cooling and shrinking mass, but while this is a proper step there is too much tendency to choke the neck of these heads, in order to make them more readily detached from the casting afterward, forgetting that the whole point of excellence is in giving free feeding power from the body of the head. Thus a casting may have several heads 12 inches in diameter and say 20 inches high, throttled to 6 inches diameter where they join the shape, instead of allowing the full diameter to continue clear to the casting proper. Another sample of ignorance of hydrostatic laws by some foundrymen is the assumption that the greater the weight of the head the greater will be the pressure on the fluid in the mold, independent of the height of the head, so that short heavy heads are often used instead of high ones of less diameter, and lack of solidity is wondered at.

Blow holes and porosity are often overrated in their importance as defects. They are not in crack form, nor are they crack starters. They merely take out a certain quantity of metal, and thousands of perfectly serviceable castings are condemned for this cause owing to lack of professional knowledge on the part of the inspectors. There are many parts of machinery in which not even the smallest defect can be permitted, but there are many other parts where small blow holes or even shrinkage cavities can in no way lead to disaster or inefficiency.

Surface machining of castings at the foundry, especially of important flanges, pistons and shafts, will undoubtedly repay the maker for the outlay. By thickening up on the cope side and roughly machining the portion added, there is an assurance of solidity which will avoid many a rejection at distant works of the builders and the consequent expense of replacing. We would urge the importance of adequate machine tools to a steel foundry as a profitable investment.

There are several "secrets of the trade" which are possessed by steel founders here and there, even while all the general steps in the business are common property. While it is not the province of a professional paper to disclose any particular processes the knowledge of which may be held as confidential, there is no impropriety in mentioning the fact that with certain washes for the mold some makers are producing steel castings which vie with cast iron in the smoothness and perfection of their surfaces, and that also improved methods of molding have greatly lessened the liability of the appearance of small cracks on the surfaces of large fillets in certain kinds of radial shapes. Castings of very thin section are the most difficult to produce, especially where thin and wide webs connect heavier sides, yet even along this line much progress is being made, and a rivalry with drop forgings is already springing up. The great tendency to decrease the weight of machinery per indicated horse-power is assisted by the readiness with which cast steel lends itself to the production of light and strong structures. The government uses vast quantities of it in machine construction, and from what has already been published we gather that before many years have passed the large guns and even the heaviest armor plate may be cast. The element of time, especially at a critical period in our national affairs, would make the adoption of cast armor plate a boom indeed, could the results be made to closely approximate the slowly forged and tempered product, and it is a question now being seriously considered whether our battleships can be supplied with their necessary protection at short notice by the foundry instead of the hammer and the press. Expensive experiments would of course have to precede any ultimate success, but that such work will be some time done is scarcely to be doubted.

THE FOUNDRY.

The foundry of H. Bollinckx, at Brussels, Belgium, is illustrated in this issue.

Writing of foundry office work a "Foundry Clerk" goes into the details connected with keeping track of things in the larger establishments. He says in part:

"While an order given to a foundry is made out for something which did not exist just then, the order given to a hardware store is contrary to such condition; consequently the hardware man is able to fill an order quicker than the foundry man can do it.

"Along with an order sent to a foundry we may find one or more patterns and coreboxes, with many loose pieces; very often also blue prints. Besides all this, there may be chills, or there may be rods, shafts, brass linings, hooks and whatsoever should be united with a casting. By looking at the order we find something particular said about the pattern, the core, the metal, the time when castings are wanted and so forth. All of this, taken together, forms the character of an order, and this character must be well understood by a foreman, so that he may be able to comply with the wishes of the customer. All such particulars should also be observed by the practical clerk, so that he may, by a way of remarks on molder tickets, guide the molders and coremaker, or by a way of remarks in the foundry sheets, guide the weighman or shipping clerk."

Paul R. Ramp takes the ground that a slag hole is not necessary in foundry practice. An idea of his arguments may be gathered from the following:

"Among the majority of foundrymen the slag-hole is a strict essential; but I say it is not. When you cannot run your cupola three or four hours without one, your cupola is not built right. Have good tuyere location and the right amount of blast pressure and you will never need a slag-hole. It is very true, with a soft blast, that flux will aid the impurities to pass off through a slag-hole, but what is the use of unnecessary bother in hauling limestone and other material used for fluxing and paying a man to keep a slag-hole open when it can be avoided? We have a 60-inch cupola and use a No. 9 Buffalo blower. It is a very common thing for us to melt forty tons at the rate of sixteen tons an hour without the aid of flux or slag-hole, and have the bottom drop clean every night. Our method is this: We use 1,000 pounds of coal and 900 pounds of coke for bed; 140 pounds of coke between

each charge, each charge of iron being 2,000 pounds, which averages a little over a ratio of one to ten in a forty-ton heat. We use 15-ounce blast pressure, and that, coupled with the fact that the furnace has twenty-four tuyeres, sixteen being four inches in diameter and eight three inches in diameter, gives us enough heat to keep the slag above the liquid metal all through the heat, and consequently what is not blown out of the stack is held up until the bottom is dropped. Now this is not paper practice, but this cupola has been run in this manner for the last ten years to my knowledge, always with good results. Some will say, such high pressure burns the iron, but that is a mistake. This firm has been making castings for seven different railroads, and always gives satisfaction. Anyone knows that poor iron cannot be put into castings for locomotive cylinders and Corliss engines and give good satisfaction. So much for burnt iron. And some might say, we burn too much fuel by using a high-blast pressure. But a firm whose time is worth about $40 or $50 an hour, which is the most economical—to spend an hour longer in melting or to use a little more fuel? Maybe the reader will say, we have not the same tuyere location. It would take but a few heats to pay for a new set of tuyeres with the time saved by our method. There are a great many advantages in this method; first, hot iron; second, clean iron, perfectly free from slag, and last, but not least, labor and time saved. And in conclusion let me say: Hot iron makes clean castings, because hot iron is purer than dull, sluggish metal. And you cannot get hot metal by slow melting. The quicker the fuel is consumed, the greater the heat."

In "Cast Iron Notes" Mr. Keep answers the question, "Can cast steel scrap be changed to soft iron?" as follows:

"Not by melting in a cupola or by any addition. A small portion of such scrap can be added to each charge of pig iron in a cupola and produce castings which will be stronger than if it had not been added. The castings will also be harder. Enough silicon iron must be added to produce solid castings.

"The cupola is not hot enough to melt steel scrap alone, and if it were possible it would be harder than before melting, if it came in contact with the fuel."

Concerning the influence on chill of additions of Bessemer iron Mr. Keep says:

"The mixture consists of 40 per cent pig and 60 per cent old car wheels, and it is proposed to add 10 per cent of Bessemer pig.

"Bessemer pig contains hardly any phosphorus or sulphur, generally manganese is less than 1 per cent. The silicon is often as high as 3 per cent, and the carbon is mostly graphite. The addition of such an iron to a wheel mixture would reduce the depth of the chill, and unless manganese was above 1 per cent would soften the chill.

"When Bessemer pig is used for car wheels it is substituted instead of charcoal iron because it is cheaper, and to regain the chill which such iron would lessen, malleable iron scrap or something similar is added. By increasing the old car wheels until the heat is substantially a remelt of old wheels the chill would be too deep, and an addition of Bessemer pig would bring the chill back again to the desired depth.

"By adding soft cuttings from boiler plate to the above mixture the depth of the chill would be increased, because the carbon and silicon would be decreased.

"It would probably have little effect on hardness of chill, though much would depend upon the character of the steel scrap added.

"Additions of both soft steel scrap and of Bessemer pig at the same time would produce a combination of the effects which would result from the addition of each separately."

F. O. Farwell illustrates a system of "Multiple Molding," which has for some time been in use at the foundry of the Adams Co., Dubuque, Ia.

S. S. Knight writes of the "Modern Foundry," and in doing so dwells with considerable emphasis upon some of the details generally more or less neglected in the average shop.

THE TRADESMAN.

Writing upon "The Unreliability of Furnace Analyses" Richard G. Moldenke says:

"I note with pleasure that you have struck the keynote of my constant endeavors to impart what little I know for the benefit of the world at large, and to give credit to and learn from even the most humble in my line of work. As a result, I am happy to say that in my official capacity as consulting metallurgist of our company, my time is at the disposal of and is fully used by all of our men in the constantly arising difficulties of their daily work. I see that we still run widely apart on the fracture and analysis question, but my impression is that this is owing to the numerous conditions which play so important a part in our work. Thus when you say that chemists aver that of two different brands of iron chemically alike, the one would chill, the other not, this would seem to me to depend entirely upon the temperature of pouring, for I have used many different brands and all have chilled when I got their silicon and manganese contents to a certain point (this point being the same in all irons having their sulphur, phosphorus and total carbon about the same).

"How long ago is it that car wheel and chilled casting people scouted the idea of using anything but charcoal irons, and the cold blast variety at that, in their work. Yet to-day coke irons are steadily crowding these clean but expensive varieties out.

"Now, as to analyses at the blast furnaces. How gladly I would agree with you in regard to the advisability of having at least the pig iron determinations made there, if it were not for the fact that in all my experience I have never yet found the analysis of a car load of iron to tally with that of the furnace, so far as the silicon is concerned. I say this with due respect for the gentlemen managing this work at the other end, for so much depends upon the manner of taking the sample; then after it is taken, how the iron is piled, and finally if the iron thus analyzed really gets into the car properly.

"I came across an instance of this kind a few months ago, which I will relate; but first I must digress a little. It is my invariable rule, after selecting my help by a process of weeding out unsatisfactory and unreliable individuals, to inform every man of the object of any order that I may give him. In this way I create a feeling of responsibility and the desire to learn more; all

my assistants, boys and laborers, being eager to point out to me any variation in the regular run of things at once. Thus does rigid discipline, coupled with a regard for the feelings of others not situated so well, invariably pay in the long run, and many a point of information have I been able to acquire by a quiet hint received at the right time.

"To return: A car was being sampled according to my usual custom of breaking ten pigs taken from different parts of the car while unloading, and then sending them to the laboratory for drilling and analysis. The laborer came to me with the information that a lot of the pigs looked different, broke easily, and the fracture looked more like a No. 4 than a No. 1 iron. I had these odd pigs laid aside, and subsequent analysis showed them to run 1 per cent less in silicon than the balance of the car load. As the iron was to be low in silicon in the first place, this was a serious matter, and correspondence with the blast furnace brought a promise to investigate and report. The latter, by the way, I have still to see. While the standing of the makers of this pig iron is above reproach, yet this instance will go to show that the iron bought and intended to be sent does not always reach the customer, and indeed in one industrial town not far from Pittsburg, it is the standing complaint of steel makers that the blast furnaces send them anything that comes along, regardless of specifications.

"The question of the utility of chemical analysis in the individual foundry is one which can safely be left to the future. In business matters 'each man for himself' is the motto seemingly adopted by the trade, and therefore when one founder notices another getting ahead of him in quality and quantity of output, he will quickly try to discover the cause. Should it be the use of chemistry in the other man's business, that would settle the matter for him quicker and better than pages of arguments."

Commenting upon the foregoing Mr. Putnam says:

"Dr. Moldenke's letter in this issue contains matter of deep interest to the foundryman. His position on the question of fracture and analysis is, from the standpoint of his own experience, unassailable. It is true that all iron does not run uniform

throughout the carload. In foundries where accurate knowledge of the chemical content is necessary the immediate presence of the analyst is of course important. But he says that the laborer who was unloading the car recognized the difference in grade by fracture, and the subsequent analysis seems to indicate that the laborer guessed the grade of the lower silicon iron pretty accurately. The situation in Pittsburg, where, as Dr. Moldenke says, the furnace ships any grade it pleases, regardless of specifications, would seem to be rather peculiar. Can it last? Is the demand for iron so nearly equal to the supply as to render the furnaceman indifferent to the good will of his customers?

"If the variation in grade in a single carload is so great as to render necessary analysis of more than one pig, then how many pigs must be analyzed to insure accuracy? I am aware that, to the cursory reader, my position on this question may appear to be diametrically opposed to that of Dr. Moldenke. But he would be mistaken. The employment of chemistry in the foundry is all right wherever it will pay. But I doubt that it would at present pay in the general run of foundries."

The same writer says of "Molding Bevel Gears":

"A molder used to have about all the time he wanted when molding a large bevel gear; but it isn't that way now, and so the practice of anchoring the cores between the arms is avoided, simply by lifting the pattern with the cope. The foregoing will be sufficient explanation for some, but as there are many who will not understand the distinction, I will explain more fully.

"The common practice in many foundries is to bed the gear pattern on its back in the cope; then, after ramming up the drag, to roll over, and joint down to the bottom edge of arms; then to set cast iron anchors between the arms, fill with sand, and make another joint at top of arms. After molding and removing the cope the anchors containing the cores are lifted and set aside, each being numbered to correspond with number inscribed in joint of mold outside of pattern. After the pattern is removed and the mold is finished the anchored cores are returned to place, being guided by say three conical projections on under side of anchors.

Before closing on the cope, the careful molder will probably 'shave' it a little on that part of the joint that might possibly press down too heavily on the over-hanging core, above the teeth. I ought not to have omitted the very important matter of 'rodding' the cores. The portion of the core that projects over the teeth will break off if not well supported by rods judiciously laid in as the cores are being built up.

"The other and better way when practicable is to cope clear down to the bottom of the arms. Of course the arm cores must be anchored, but in this case the anchor stems reach clear up through the cope, and anchors, cores and gear pattern all are lifted with the cope. It is quite possible that a few of the teeth may be somewhat disturbed by this, but that is a matter easily 'mended.' Now we have simply to draw the pattern from the cope, and the mold is ready to close. If you have never tried this plan you may feel a prejudice against it, but try it once and your prejudice will vanish—that is, if you do the work properly."

Speaking of "Feeding" or, as it is sometimes called, "Pumping," Mr. Putnam writes:

"How long shall a mold be 'pumped' in order to insure solidity? This question is often asked. Most molders who are accustomed to this class of work will know when to stop; but there are many foundries where such work is done but seldom, and where the philosophy of feeding is not well understood. It is only safe to have a feeding head of large diameter and considerable depth, and then to pump nearly or quite as long as it will take iron; that is, until the feeding head shall be solid. You may stop somewhat short of this extreme when you get used to the business. I have seen men stop pumping at about the time that the iron is in condition to require the pumping to begin, and then wonder that the casting was not solid. A fluid connection must be maintained from feeder to center of casting till solidification."

CANADIAN MINING REVIEW.

This journal, in its February issue, contains the following paper, presented by Ernst A. Sjostedt at the Montreal meeting of the Federated Canadian Mining Institute on

The Chemistry of Foundry Practice.

Compared with the chemistry of the blast furnace process (in which the ores are deprived of their oxygen, and the reduced metal combines with such elements as carbon, silicon, manganese, etc.), and the different processes of iron and steel making (whereby the said foreign ingredients are oxidized and eliminated to a more or less complete degree), the chemical changes taking place in the cupola, where the metal is merely remelted, are quite simple. Nevertheless, these changes, small though they be, are sometimes of great practical importance, and as the physical qualities of the castings, such as strength, hardness, elasticity, etc., are very largely dependent on the chemical composition of the metal, it is evident that the adoption of chemical researches in connection with the foundry practice are well deserving of a most careful attention. The importance and necessity to the blast furnace manager and the steel maker of applying chemistry in their daily practice has long been recognized, but it is quite recently that the services of the chemist have been called upon to help solving the many puzzling problems which the foundryman constantly encounters. However, his legitimate place and position is already well established at the larger foundries in the United States and in Europe, besides at such works where a specialty is aimed at, such as car wheels and malleable castings; and the smaller foundries are slowly following their example.

In the hopes of arousing some interest in this important subject in this country, and especially among the members of this association, the following notes and facts are hereby presented as a nucleus for discussion—founded as they are on the best authorities, and in all essential parts having been found correct and a most valuable help to the writer, in connection with his labors and investigations as chemist at different iron and steel works. Even at the risk of appearing pedantic the writer has aimed at making this treatise as elementary as possible, in order to interest those least familiar with the subject, and must therefore ask of the well informed members their kind forbearance.

As we all know, absolutely pure iron does not exist as a commercial product, for what we are working and dealing with is not

a single substance, but an alloy, composed of a number of elements in different proportions, the total sum of which, however, seldom exceeds five to ten per cent. Among these elements, carbon is an essential constituent and one that plays a most important role in determining the physical character of the iron. In fact, its influence on the iron is so great that its presence in smaller or greater amounts is responsible for the three well known classes, with so distinctly diffeent characteristics, in which iron has been divided, namely wrought iron, steel, and iron pig—pig iron containing about 2.5 to 5.0 per cent of carbon, steel from .4 to 2.5 per cent, and wrought iron from about .03 to .35 per cent; and their characteristics are so familiar to us all that it is here only necessary to recall their different melting points, which for pig iron is from 1,800° F to 2,200° F, steel about 2,650° F, and wrought iron about 2,880° F. Again, we must carefully keep in mind that carbon, in pig iron, occurs in two conditions which are distinct in their physical and chemical relations, namely as graphite and as combined carbon. If present as graphite (i. e., simply mechanically mixed with the iron), the pig has a gray, soft fracture, but when it is in chemical union with the iron the fracture is white and hard, with metallic luster. In molten pig iron all the carbon is present in its combined form, and it all depends on the time and conditions allowed during cooling which state—graphitic or combined—it will assume in the casting. The slower the cooling is taking place the better opportunity the carbon will have to crystallize (forming graphite) and the grayer the iron becomes, whereas if made to cool suddenly (as when poured against a chill block) the carbon is not given this opportunity, and consequently it remains in its combined state, and the iron becomes hard and white—always provided no other strong agent is present that will break this rule, and of which we will speak presently. The carbon, per se, as long as it remains combined in the pig iron, increases the absolute tensile strength of the iron, but when separating as graphite it makes the iron weaker; it also increases the hardness, but decreases the elasticity and the melting point of the iron (i. e., white pig iron is somewhat easier to melt than gray). The following analyses

of combined and graphitic carbon in a certain coke iron will give a clear idea of the influence which the different modifications of the carbon exert on the fracture of the pig:

No. 1 Foundry pig...3.80 p.c. graphite, and.... .10 p.c. combined carbon
No. 2 Foundry pig...3.78 p.c. graphite, and..... .25 p.c.combined carbon
No. 3 Foundry pig...3.60 p.c. graphite, and.... .39 p.c. combined carbon
Gray forge.....1.50 p.c. graphite, and.... .70 p.c. combined carbon
Mottled.....1.50 p.c. graphite, and....1.70 p.c. combined carbon
White..... .10 p.c. graphite, and....3.10 p.c. combined carbon

Among the other elements usually present in the pig iron, and the one next to carbon in importance, as regards its effect on the iron ,we must place the silicon. Silicon, namely, exerts a controlling influence on the chilling properties of the iron, owing to its tendency of separating the carbon as graphite. Its percentage in the pig iron is generally in proportion to the temperature at which it has been manufactured—thus a coke iron is higher in silicon than a charcoal pig—and varies from a few tenths of one per cent (as in Swedish charcoal pig) to 1.5 and 2.0 per cent (in iron usually suited for machine castings), and runs as high as 2.5 to 3.5 per cent in good soft coke iron, and the "silvery iron" contains about 4.0 to 5.0 per cent. Silicon alloys with iron in greater proportions than carbon (ferro-silicon containing 30 to 50 per cent), and decreases the absorption of cabon—hence coke iron is generally lower in total carbon than charcoal pig, and iron with 2 per cent silicon and no manganese has seldom more than 3.8 per cent carbon. It increases the fluidity and fusibility of the iron and lowers its melting point, retaining its heat for a longer time, and thus lessening the formation of blowholes, and decreases the shrinkage (in proportion to the amount of graphite that has separated). Added to "pure cast iron" it has been found to improve the strength of the iron up to 2.5 per cent, above which amount, however, it makes the iron weaker. From the above properties of the silicon it is easy to see why it is that pig iron which contains a high percentage of silicon acts and is used as a "softener," and that by melting various portions of such iron with hard iron all the different grades can be obtained, from close to very open grained soft iron—in remelting, pig iron loses

about .25 per cent of silicon, which should not be lost sight of.

Another disturber of the equilibrium in a pig iron is sulphur. Contrary to silicon, sulphur prevents the formation of graphite, and consequently it has a tendency of producing a white hard casting; it also makes the iron sluggish and full of blowholes, causes red shortness and increases the shrinkage. Besides, being generally irregularly distributed in the iron, sulphur tends to make an uneven, unreliable casting. For these several reasons sulphur has well been called "the foundryman's bane," and (owing also to the hindrance it offers to annealing) it should especially be avoided in malleable castings, also in iron intended for car wheels. Sulphur has a great affinity for iron, combining with it at a low temperature and in any proportion up to about 53 per cent.; and as its evil effects are perceptible already at a fractional part of one per cent., it must be a matter of great importance for the foundryman to keep track of this element. As a general thing, it is rarely found in a soft open foundry pig—for its presence to any high degree would make the iron more or less close grained or white—and this great enemy, therefore, is not always shunned as much as it deserves; but its presence in the coke, and sometimes also in the limestone, is certain to bring it in the iron, and thus it happens that a good iron often has been condemned when the fuel and the flux alone were to blame. Good Connelsville coke contains seldom over .6 per cent. sulphur, but at many a foundry 1. per cent, of sulphur in the coke is not unusual; and if a basic flux and a high temperature be not resorted to in the cupola the iron, in remelting, will increase .2 to .5 per cent. in sulphur, which is sufficient to spoil it for most purposes—if the silicon be not present in sufficient quantity to neutralize its effect.

The powerful influence of sulphur in changing the character and fracture of the pig iron has more than once been forcibly brought to the personal experience of the writer, and an extreme case was met with several years ago at Kathadin Iron Works, Maine, with iron made from a bog ore that contained from 1. to 3. per cent. of sulphur, and which at the time was only imperfectly roasted. Analysis of several samples of all grades of this pig iron—from open gray to white and spongy—revealed the

presence of sufficient silicon which, under ordinary circumstances, would have made them all gray and soft, but the varying amounts of high sulphur present were here the determining agent, as we see from the following table:

	No. 1	No. 2	No. 2	No. 3	No. 3	No. 4	No. 4	No. 5	No. 5	No. 6	No. 6	No. 6	No. 6
Silicon	3.09	3.10	2.35	3.55	2.00	2.74	2.70	2.22	1.80	3.89	3.05	2.73	1.26
Sulphur.....	.03	.18	.18	.39	.10	.20	.34	.02	.18	.60	.46	.65	.43

Here, thus, we have a white iron with nearly 4. per cent. silicon, which but for the .6 per cent, sulphur present would have shown an open, soft gray fracture.

An element we often hear about, and which, when present even in the smallest quantity in steel, is much dreaded, is phosphorous. In foundry pig, however, a certain small amount is not only permissible, but highly desirable, as it lowers the melting point of the iron and makes it fluid, thus causing it to retain its heat longer and making it suitable for producing small castings of a delicate pattern. Pig iron with less than .2 per cent. phosphorous is apt to shrink.

But when it is present to over .75 per cent. the iron becomes brittle—this in proportion to an increased percentage of carbon present—and strong castings should not contain over .5 per cent. of phosphorous. It unites readily with iron to about 26 per cent., but practically the pig iron in the market contains from a trace to 1.5 per cent. Phosphorous is not eliminated in the cupola smelting, and its presence should, therefore, be kept run of.

Manganese is also an element to be taken in consideration in foundry practice, for so many iron ores contain this metal, and a certain amount enters the iron during the blast furnace process, while part combines with the lime and the sulphur and is removed with the slag. Its most striking property is to make the iron "chill," i. e. prevents formation of graphitic carbon. But this chill does not make a durable wearing surface, as it is more crystalline than hard, and readily crumbles under the impact of rapid shocks (to which e. g. a car wheel is subjected). Its presence up to 1 per cent., however, is not considered detrimental, but a high percentage of manganese makes the casting brittle and white—

provided the silicon is not exceptionally high, in which case (as in some Scotch foundry pig of good repute, which carry 2 to 3 per cent. of manganese), the graphite is separated, and a gray iron obtained. Iron alloys with manganese in all proportions, and when the amount of manganese runs between 20 and 80 per cent. the product is called ferro-manganese, and when containing from 5 to 20 per cent. it is termed "spiegel" iron. Manganese raises the point of saturation for carbon, i. e. permits of a high total carbon. Iron without any manganese rarely contains over 4.5 per cent., but ferro-manganese often from 5 to 7 per cent. of carbon (nearly all of which is in the combined state). Owing to its affinity to sulphur, it acts as a "purifier," even more so than lime, in the cupola, removing oxides of iron and silicon from the molten iron, and thus helps to prevent blowholes.

A metal which during the last decade has come in great favor as an admixture to iron and steel is aluminum.

The credit of first calling attention to the influence of aluminum on iron castings belongs to a Swedish inventor, who introduced the so-called "mitis" castings—a mixture of wrought iron and aluminum. The principal effect this metal has upon cast iron is that it lowers the melting point of the alloy, consequently increases its fluidity and makes it run quick and sharp, besides giving the gases an opportunity of escaping from the molten iron —hence its reputed quality of preventing blowholes. Like silicon, aluminum tends to make a gray iron, and lessens the tendency to chill (i. e. favors the formation of graphite), and if allowed to take the place of silicon, it will make a stronger and softer casting than if silicon were the agent; but added to an iron already high in silicon, it makes it weaker. An addition of aluminum, therefore, is beneficial only to a low silicon pig. If added in sufficient quantities (2 per cent. and more) aluminum, for the same reason as silicon, prevents shrinkage.

Other elements, such as titanium, arsenic, copper, nickel, chromium, etc., also exert their influence on the character of the iron, but they rarely occur in sufficient quantities to require looking for.

From what already has been said, it follows that carbon is a necessary but passive component in the pig iron, made to change in amount and in form by the presence of other elements. Thus sulphur and aluminum, and to a lesser degree silicon, cause it to release, while manganese enables it to hold more carbon in solution; silicon and aluminum tend to change the carbon into graphite, while sulphur, manganese and phosphorous do not cause carbon to leave its combined state. Sulphur, manganese and combined carbon increase the tendency to shrinkage, while silicon and phosphorous help to counteract this evil—and the more of the effective element the iron contains the more is its action facilitated or retarded, as the case may be.

According to the state in which the carbon is present in the pig iron its grading is determined; but as we have also seen how largely the proportional amounts of graphite and combined carbon are dependent on the many foreign elements present, and to a great extent also on the conditions under which the metal has been allowed to cool, it will at once be evident how uncertain and unsatisfactory it must be to try to judge the quality of the iron simply from the fracture it presents. On the other hand, it is not claimed that the physical properties of an iron are wholly dependent on a certain chemical composition—for there are several possible and proper compositions for an iron intended for any certain purpose—each of which depends for its physical success on the manner of working the iron, as the fuel, blast, temperature, etc., and on the relative proportions of one element to another, as well as on the actual amount of each present—but before we institute chemical investigations we do not gain a true knowledge of what causes these different physical qualities in the iron, nor is it otherwise possible to ascertain the true composition of the pig iron or the cupola charge. In trying to remedy any evil, the first step to be taken, after all, is just in this direction of discovering its cause, after which a restorative generally can be found. For in forming his deductions, the chemist's mode of procedure is singularly simple, reasonable and practical; as a result of years of scientific experience, theory and actual practice, it is known that certain impurities in the material produce certain characteristic

effects on its physical behavior; and these impurities may be eliminated, retained or forced into combinations with others, according to fixed laws and conditions to which they are subject. "There are foundries that can get along without chemical service, but they are very few who could not obtain practical benefit from a use of the knowledge now obtainable upon this question."